

## OPERATION AND MAINTENANCE PRACTICES FOR MAINTAINING OPTIMUM INDOOR AIR QUALITY

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The quality of the indoor air to which occupants are exposed, particularly in the office environment, has become of increasing concern during this last decade. Various investigative studies into "sick" and "problem" buildings indicate that a significant percentage of building occupants are exposed to indoor environmental conditions which may result in adverse health effects, occupant discomfort, and reduced employee performance and productivity. The results of numerous indoor air quality investigations by researchers of the Georgia Tech Research Institute (GTRI) and others have shown that design inadequacies and poor building operation and maintenance (O&M) practices are the primary categories which dominate sources of air quality problems.

Frequently poor O&M practices are the result of improperly installed and inaccessible HVAC systems and ductwork, lack of training of facility maintenance and management staff, cost restrictions, lack of understanding of the importance of maintenance practices, improper use of chemicals and cleaners, or attempts at energy conservation. Design inadequacies can also be the cause of poor O&M practices. O&M practices are defined here as applying to all aspects of building operation and maintenance including HVAC, custodial services, renovation procedures, pest control practices, smoking policies, etc.

The cost of poor indoor air quality can be quite costly for employers. A conservative estimate for annual salary costs is \$200 per square foot. The typical annual average office building heating/cooling costs are about \$2 per square foot. Salaries are the most significant of all operating costs in almost every company. Poor O&M practices which result in decreasing indoor air quality can be counterproductive to employee and tenant productivity.

## HOUSEKEEPING AND CLEANLINESS

Cleanliness and housekeeping of the building and mechanical-ventilation areas are extremely important. Dust should be removed daily, not just stirred around. Soap and water should be used in bathrooms and food preparation, storage, and eating areas in place of highly perfumed cleaners. The use of aerosol sprays should be minimized. The storage of chemicals in the area used for return and outside ventilation air can result in contamination of the occupied areas with these chemicals. The use of highly perfumed products and deodorizers can trigger hypersensitivity reactions in building occupants. GTRI researchers have investigated several different incidents where the use of highly perfumed products have triggered hypersensitivity reactions.

**Case 1:** In one study, the occupants were complaining of headaches, nausea, respiratory problems, and odors. The problems had increased significantly in the month prior to the investigation. The fourth floor, the floor with the most complaints, had a strong sickly-sweet odor. It was discovered that the maintenance staff had sprayed a vanilla-scented deodorizer on the primary HVAC system filters when they replaced the filters. They sprayed the deodorizer on the filters in response to occupant complaint of foul, rotten garbage-like odors permeating throughout the fourth floor. Inspection of the building air intakes revealed that six sewer roof vents were located directly in front of the building air intake. Strong sewer gas odors were emanating from the vents and the odorous air was being drawn into the building ventilation system and distributed throughout the occupied zones. This design inadequacy resulted in poor O&M practices resulting in human responses of discomfort.

**Case 2:** The emissions from continuous-feed bathroom deodorizers resulted in occupant complaints of respiratory problems, eye irritation, nausea, headaches, and lethargia. The office areas were filled with foam-filled modular office partitions. The partitions emitted strong odors of the grape-scented bathroom deodorizer used in the buildings. It was found that the bathrooms exhaust was vented to the top of the elevator shafts. When the elevator operated it created a vacuum in the bathroom

drawing bathroom deodorizer emissions into the elevator shafts and distributing it throughout the building. The foam-filled modular office partitions served as sinks for the bathroom deodorizer emissions and then became secondary sources of the contaminants. The result was that over time high levels of the deodorizer contaminants existed in the occupied zones and caused irritation effects among the occupants. As in Case 1, design inadequacies combined with poor O&M practices resulted in human discomfort complaints.

## PEST CONTROL

Improper application of pest control has been resulted in a plethora of homeowners complaints. The frequent improper application of chlordane was one of the major contributing factors to its being banned. Pest control should be applied during periods of inoccupation with increased ventilation and according to the manufacturers' directions. Building occupants should be aware of the hazards of personal use of pesticides.

**Case 3:** The occupants of a business office sought medical help after suffering chemical burns in their respiratory systems and in their mouths, having headaches, lethargia, and other symptoms of poor indoor air quality. The office was in a larger office complex. The occupants of the business office were the only people in the complex suffering symptoms. Investigation into the building revealed that there was poor ventilation efficiency in the space, but nothing in the building design indicated this the cause of the sudden onset of severe symptoms although the area had a chemical smell. Upon questioning of the occupants, it was learned that they had been spraying the space regularly, several times a day on and around their desks with pesticides. They also said that the weekend before they became so sick that they had released two bug bombs. The office complex turned off the ventilation system on the weekends as an energy conservation measure. When the occupants returned for work on Monday morning, the pesticides were still in the air since there had been no ventilation of the space to remove the contaminants. The business office residents did not follow proper usage guides for pesticides.

## HVAC SYSTEMS

Inadequate design of HVAC systems frequently results in poor O&M practices. Inaccessibility is one of the most common poor design features encountered.

Case 4: Complaints of headaches, lethargia, and confusion were being expressed by the occupants of a combination emergency medical facility and office building facility. The building had three roof-top ventilators were only accessible by climbing a steep ladder located in an extremely small, crowded storage room. The door to the roof was a heavy trap door which could only be opened and closed by precariously hanging from the ladder. The maintenance personnel had removed the filters from the roof-top systems rather than risk life and limb negotiating the roof access. As a result, the condensate pans clogged and water leaked into the supply ductwork and the ceiling below. Ductboard was used for supply ducts. The building had a plenum return which was fiberglass insulated on top of the ceiling tiles instead of the plenum ceiling. Insulating on top of the ceiling tiles resulted in an extremely hot and humid plenum. Therefore, when cold air-conditioned air escaped through unsealed areas in the ductboard seams, condensation on nearby surfaces occurred. This condensate dripped onto the ceiling insulation providing conditions for microbial growth. The facility manager replaced ceiling tiles when they disintegrated, but did not replace the fiberglass insulation. No effort was made to investigate the source of the condensation by the facility manager. The inaccessibility of the roof-top ventilators and the poor design and construction of the complex resulted in poor O&M practices and subsequent microbial contamination of the occupied zones of the building.

Case 5: Complaints were being received by the facility managers by the tenants on the ninth floor of a twelve story office building. The occupants of the Northwest wing of the building were suffering eye irritation, sinus infections, and sneezing and coughing fits. The occupants also complained of a dirty, musty smell which was particularly strong early in the morning. The majority of the sufferers had been diagnosed by physicians as having allergic reactions to molds. The occupants most severely afflicted were not the typical of those usually suffering reactions to poor indoor air quality. All of the victims were young, healthy, athletic individuals

who had not previously suffered from allergic type reactions. The person who was most severely afflicted was a mountain climber. During the investigation, microbial swab samples of the ninth floor air handling condensate pan, coil, outdoor air intake, and selected diffusers. Standing water was present in the ninth floor air handler. The analysis of the swab samples indicated fungal growth on the outside air intake, bacterial growth within the condensate pan and coil, and no growth on the diffusers. The genera which were detected are known to cause allergic reactions. Poor O&M practices probably resulted in airborne microbial contamination and the resultant allergic reactions among the building occupants. It was recommended that the facility maintenance personnel clean the various areas of the HVAC system with dilute chlorine bleach and hot water.

**Case 6:** In another investigation, the tenants of an office building were suffering suspected indoor air related symptoms of headaches, eye irritation, and respiratory system irritation. The tenant was a brokerage firm which did not employ chemical usage, had a single copier, and had no other obvious sources of occupant generated contaminants. This was the only area in the office complex which reported occupant symptoms. The most severely afflicted occupant reported that he could smell cigar smoke when the adjacent tenants used the conference room next to his office. These neighboring tenant was a photographic and graphics arts firm. It was discovered that in this area there were several large color and black-and-white copying systems, automatic darkroom systems, and other wet-processing copy systems. None of these systems was properly vented to prevent contamination of the recirculated air. In addition it was found that there was a break in the firewall around the building perimeter which allowed direct transference of the contaminants generated in the graphic arts firm into the brokerage firm. The poor construction of the firewall, deviation of space use from the design specifications, and lack of proper exhaustion of contaminants being generated by the processes of the graphic arts firms resulted in poor indoor air quality and occupant discomfort complaints.

## RENOVATION PRACTICES

Renovation should be conducted during periods of non-occupation and with increased ventilation. Proper commissioning of new and renovated space should be

followed. All renovation materials should be properly stored in sealed containers.

**Case 7:** A corporate senior vice president suddenly began suffering anaphylactic shock for three successive days within five minutes of entering his office. After three trips to the hospital, he instructed the building maintenance staff to find the problem with his office. Investigation showed that major renovation was being conducted on the entire floor two floors below the VP's office. On this floor, immediately below the VP's office, the wallpaper paste, paints, caulking compounds, and waste buckets were being stored. The waste buckets and several of the wallpaper paste buckets were being left open. A pathway was discovered for contaminant transference from this floor into the VP's office. The supplies were removed to a proper storage area and were sealed. Once this was done, the VP was able to enter his office without going into shock.

#### SUMMARY

Inadequate design and poor O&M practices have resulted in a seemingly large majority indoor air quality related complaints. Inadequate design frequently results in poor O&M practices. Other causes of poor O&M are laziness, lack of training and understanding, improper use of chemicals and cleaners, cost restrictions, and attempts at energy conservation. Every facility should have established O&M guidelines and policies which are designed to assure optimum indoor air quality. These guidelines should set up a schedule for O&M, renovation practices, crisis response, tenant and occupant interaction practices, provide adequate instructions and training, and must importantly the guidelines should be implemented.